Modernization of District Heating in Bucharest

Transferable Solution

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Project Title: Feasibility Study for the Modernization of TP1 and TP2 Baneasa Heating Plants, Bucharest, Romania
Leader: RADET RA, Bucharest
Partners: Advanced Engineering Associates International (AEAI**)** – USA, Institute of Power Studies and Designs (ISPE) SA. – Romania
Location: Romania
Project Duration: February 2002 – January 2003
EcoLinks Project Investment: Total Project Investment: $122,914; Ecolinks grant: $ 49,176; Team Cost Share Contribution: $ 73,738.

Best Practice: Transferable Solution

This EcoLinks project is a Best Practice because it successfully demonstrated a solution for reducing greenhouse gas emissions and generating reliable and cost effective energy by replacing old heat-only boiler plants with small-scale, combined heat and power plants (CHPs) in a large, district heating utility in Romania. Based on the research and analysis of several alternatives, a practical locally feasible solution resulting in both economic and environmental benefits was selected. This integrative methodology, involving a feasibility study a sound financial strategy, is transferable to other similar utilities seeking to improve energy efficiency and availability and service quality; and to reduce heat and power costs and greenhouse gas emissions. Moreover, data gathered from surveying residential clients' attitudes toward heat savings and related investments in their apartments and collective buildings provided an important information base that could also benefit other utility companies seeking to improve the quality and reliability of their services.

Project Summary

Bucharest, the capitol of Romania (popn. approx. 2.3 million), has a very large district heating system. The municipal energy utility, RADET, transports and distributes heat purchased from the national energy company. RADET also generates and supplies residential heat from two heat-only boiler plants (HOBs), Baneasa 1 (HOB1) and Baneasa 2 (HOB2). HOB1 and HOB2 supply heat to a large residential area in the northern part of Bucharest that is not connected to the city district heating network. HOB1 supplies space heating and warm water to approximately 1,200 apartments from its nine 1.23 MW boilers commissioned in 1981-1984 and two 1.12 MW boilers which were commissioned in 2000-2001. HOB 2 supplies space heating and warm water to approximately 1,050 apartments from its seven 1.23 MW boilers commissioned in 1981. Both plants are gas fired and emit 12,100 of tons of CO_2 per year.

With the support of an EcoLinks Challenge Grant, RADET collaborated with an US partner (AEAI) and a Romanian partner (ISPE SA) to analyze options to secure reliable and efficient heat and power generation for the northern area of Bucharest. The main purpose of the project was to cover the area's heat demand at the lowest emissions and lowest cost possible, and to ensure a consistent supply of heat to residential collective buildings. The technical, environmental and economic aspects of selecting and financing the most appropriate co-generation system were investigated in order to determine the most feasible and appropriate system. The EcoLinks project team also investigated cost effective demand side management measures in collective residential buildings. The measures included: 1) the weatherization of doors and windows; 2) the repair of warm water distribution pipes and valves; 3) the insulation of roofs, basements and staircases; and 4) the installation of control mechanisms and heat meters, etc.

The best alternative co-generation system for each plant included: one co-generation module with a gas engine and a recovery boiler to cover the summer heat demand, seven new warm water boilers for Baneasa 1 and six for Baneasa 2 to meet the winter and peak demand, and a 200 m^3 storage tank. This new system will generate approximately 30,000 MWh per year in Baneasa 1 and 23,500 MWh per year in Baneasa 2. The excess electricity generated in Baneasa 1 (8,400 MWh per year) and Baneasa 2 (7,000 MWh per year) will be sold to the grid generating income of $420,000 and $350,000 per year, respectively. With the implementation of these systems, greenhouse gas emissions are notably reduced. CO_2 emissions would be reduced by 37%; CO emissions by 29%; and NO_2 emissions by 29%.

Under the recommended option and the assumed financing terms, the project generates a Net Present Value (NPV) of approximately $266,000 for Baneasa 1 and $202,000 for Baneasa 2 with Internal Rates of Return (IRR) of 22% and 20 %, respectively, making this an attractive investment project. The heat unit cost was $20.5/MWh (5 % lower than the current cost based on the assumption that the fuel cost will rise by 55 % throughout the lifetime of the project). The project team also analyzed several project financing alternatives, including a commercial loan, a Build-Operate – Transfer contract and finally, a equipment supplier credit. The recommended solution was the supplier credit.

Project Activities

1. Conducted a technical and emissions assessment of each plant.

As part of the feasibility study on the plants' modernization, the project team collected technical data on current heat generation, operating costs, heat cost and tariffs, the state of technical equipment, and other factors.

1.1 Heat supply
Both HOB plants (Baneasa 1 & 2) are mostly equipped with manually controlled Romanian gas fired boilers commissioned between 1981 and 1984. Baneasa has nine old Romanian boilers (commissioned 1981- 1984) for space heating and two new Italian boilers (commissioned in 2000 – 2001) for warm tap water. Given the age of the equipment, only five out of the nine old boilers are in operation. The heat supplied by Baneasa 1 in 2001 was approximately 11,500 MWh for heating and 9,852 MWh for warm water. The plant used approximately 2.7 millions m^3 of natural gas per year. Baneasa 2 operates seven boilers commissioned in 1981. These boilers generated approximately 8,916 MWh for space heating and 8,607 MWh for warm tap water. The plant burned approximately 2.2 million m^3 of gas per year. The heat cost in 2001 was $21.16/MWh. This was approximately 50% more than the previous year due to a rise in the price of the natural gas. Both plants have a global efficiency ratio of approximately 80%.

1.2 Emissions released
The project team calculated greenhouse gas emissions in accordance with the Intergovernmental Panel on Climate Change (IPCC) revised guidelines for National Greenhouse Gas Inventories. Baneasa 1 and Baneasa 2 released approximately 12,100 tons of CO_2, 32.5 tons of NO_2 and 4.3 tons of CO in the year 2001.

Product(s): Technical data on the plants' equipment, heat generation and emission levels

2. Conducted a household survey on heat use.

The team also prepared a questionnaire for residents and housing associations in the area on their current living conditions, level of satisfaction with heat supply services, residential improvements to save energy and increase indoor comfort, interest in energy efficiency, availability to make larger energy efficiency improvements in their apartments or collective buildings and other factors. Landlord and tenant associations were surveyed on the current state of building installations, basements and roofs and plans for investing in energy efficiency improvements. Six hundred questionnaires were sent to individual households and 60 were sent to landlord and tenant associations. The response rate was 32% for households and 45% for associations.

The project team analyzed the survey results and concluded the following:

- Although most of the buildings in the target area are less than 20 years old, the overall technical state of the buildings is not satisfactory given the 90-year lifetime standard. It was estimated that 20 % of the supplied building heat is lost.

- Many radiators are encrusted with organic and inorganic deposits as they have no filters or sludge separators. Room heat transfer was estimated to be 12% lower than normal. Only 40% of those surveyed had cleaned their radiators in the past two years.
- Less than half of the respondents (44%) had replaced in-door sanitary installations with more efficient ones.
- Only 2.6% of the respondents had individual heat and warm water meters. When asked about the installation of a meter system, the vast majority of the respondents prefer to have meters installed at the block entry level (90%) as well as at the apartment level (82%).
- Approximately one-third of the respondents indicated that they had undertaken measures to seal doors and windows. Another 17% of the households indicated that they had replaced traditional doors and windows with highly insulated ones. Approximately 21% of surveyed landlords indicated that such measures would be implemented in the future.
- Eighteen percent of the surveyed landlord and tenant associations reported that they made repairs to basement heat pipes and valves in basements. Nine percent reported that they had weatherized door entrances and windows. Five percent had indicated that they had installed heat meters at the building level. Some associations (18%) intend to continue repairing and insulating the basement heat pipes and valves. More than half of the associations (58%) will apply a metering system to measure heat usage and 13% indicated intentions to weatherize entrance halls. Seventeen percent respondents anticipate the installation of thermal building insulation.
- The general rating of the heat supply services was good; nevertheless, some 5 associations (18%) of the total expressed interest in installing heating boilers in their buildings and thus disconnect from the district heating.

The project team prepared also three energy efficiency investment packages for the information of tenants/owners of apartments. These include:

Low cost measures:

Sanitize basements, repair and insulate heat pipes, weatherize building entrance door and windows, weatherize apartment entrances and windows, clean radiators, replace control valves on radiators, install individual gas meters for cookers, among other measures. The package cost was estimated at $6.75/sqm, or $297 per average apartment. This is expected to save 2.53 MWh per apartment per year, resulting in a simple payback period of 4.47 years.

Medium cost measures:

The above measures plus thermal roof insulation, the insulation of floors over basements, insulation of specially exposed walls, and elimination of thermal bridges in buildings' structures. These measures are estimated at $41/sqm, or $1,801 per apartment and are expected to save 5.32 MWh/year per apartment, resulting in a simple payback period of 13 years.

High cost measures:

The above measures plus building envelope insulation and sun protection for extra hot seasons. The investment was estimated at $3,636/apartment and the savings at 6.87 MWh/year per apartment; resulting in a payback period of approximately 20 years.

Product(s): Survey report and investment packages

3. Estimated the future heat demand and identified technical solutions for modernization.

3.1 Heat demand

An analysis of the heat demand/supply curve for the years 2000-2001 was conducted. The project team also calculated future heat demand for the area. The forecasted heat demand for Baneasa 1 and 2 are as follows:

	Baneasa 1	Baneasa 2
Winter peak	11,130 kW per hour	8,858 kW per hour
Winter average	4,489 kW per hour	3,966 kW per hour
Summer average	1,151 kW per hour	1,012 kW per hour
Total heat demand	29,800 MWh/year	23,400 MWh/year

A survey, performed by the project leader in the service area, revealed that there is minimal interest amongst new consumers to subscribe to district heating services. As a result of disconnecting from the district heating system, reductions in heat demand are not expected to exceed 1 % of the present heat demand for each of the two HOBs. The findings of the survey were used to investigate technical options for modernizing the two HOBs with co-generation units or only new heat boilers.

3.2 Technical alternatives for plants modernization

Three alternatives for HBO modernization were analyzed based on technical considerations and cost effectiveness. The alternatives are as follows:

Alternative 1

Alternative 1 included:

- the replacement of old boilers with three modern co-generation units that would cover the average (medium) winter heat demand;
- four new modern warm water boilers would be used for satisfying demand during winter and peak periods; and
- a 200 m^3 storage tank that would be used to level the load of the engines.

Heat demand by both areas as well as the plants' own electricity consumption would be met, and surplus electricity would be sold to the National Power Company.

Alternative 2

Alternative 2 consisted of:

- one co-generation module with a gas engine and a recovery boiler system to meet summer heat demand
- seven warm water boilers for Baneasa 1 and six for Baneasa 2 to fulfill heat demand during winter and peak periods; and

- a 200 m^3 storage tank.

Heat demand by both areas as well as the plants' own electricity consumption would be met, and surplus electricity would be sold to the National Power Company.

Alternative 3

Alternative 3 included:

- only boilers with no co-generation units; and
- in addition to the two existing Italian boilers for warm water, eight new boilers to cover both average and peak winter demands.

No electricity would be generated by implementing this alternative.

A summary of the analysis of each of the three alternatives is presented in Table 1.

Table 1. Analysis of Each Alternative for Baneasa 1 and Baneasa 2.

	Alternative 1	Alternative 2	Alternative 3
Baneasa 1			
New configuration	3 gas engines x 1,237 kWe 4 new boilers x 1,279 kWt	1 gas engine x 1,237 kWe 7 boilers x 1,163 kWt	8 boilers x 1,279 kWt
Heat output (MWh/year)	29,788	29,788	29,788
Electricity output MWh/year	18,098	9,005	0
Fuel consumption (million Nm^3/year)	5.7	4.6	3.5
Investment costs ($ million)	3.077	1.274	0.396
Operating costs ($ million)	1.261	0.906	0.658
Baneasa 2			
New configuration	3 gas engines x 1,033 kWe 4 new boilers x 1,279 kWt	1 gas engine x 1,033 kwe 6 boilers x 1,279 kWt	8 boilers x 1,163 kWt
Heat output (MWh/year)	23,416	23,416	23,416
Electricity output (MWh/year)	14,811	7,401	0
Fuel consumption (million Nm^3/year)	4,599	3,659	2,719
Investment costs ($ million)	2.602	1.098	0.360
Operating costs ($ million)	1.010	0.717	0507

3.2 Environmental assessment of the alternatives

Emissions were calculated for each alternative and compared to current emission levels. The results are presented in Table 2.

Table 2. Analysis of Emissions: Present Situation and Alternatives 1-3.

Emissions	Present Situation	Alternative 1	Alternative 2	Alternative 3
Baneasa 1				
CO_2 (tons/year)	20,160	10,600	15,200	19,700
NOx (tons/year)	46.27	28.48	36.88	45.20
SO_2 (tons/year)	27.52	0	13.83	27.52
CO (tons/year)	6.10	4	4.88	5.95
Baneasa 2				
CO_2 (tons/year)	16, 280	8,470	12,220	15,960
NOx (tons/year)	37.30	22.76	29.60	36.43
SO_2 (tons/year)	22.52	0	11.27	22.52
CO (tons/year)	4.91	3	3.92	4.8

A number of the top ten manufacturers of gas engines and boilers were contacted to obtain information on system components and costs. All offers were compared according to reliability, price, operation costs, emission levels, and efficiency.

4. Conducted a simplified cash flow analysis and selected the best energy system option.

A simplified cash flow analysis was performed for all three alternatives (two with co-generation modules and one with only new heat boilers). The simplified cash flow analysis consisted of the following framework:

- an electricity selling price of \$50/MWh;
- a lifetime of 20 years for the installation;
- a natural gas purchasing price of \$125/1000 Nm^3;
- maintenance and operation costs at 3 % of the investment for the co-generation modules and 1 % of the investment for warm water boilers;
- insurance costs estimated at 0.055% of the total investment costs; and
- 85% investment financing, with a discount rate of 10%, would come from a bank loan and 15 % from the project sponsor. The bank loan terms were assumed as follows: tenure (15 years with a one year grace period); interest rate, fees and taxes in US dollars (10%), other financial costs (2.783%); and corporate tax (25 %).

Two simplified project cash flow analyses were conducted including and excluding calculated income from the sale of carbon credits. Table 3 summarizes the simplified cash flow analysis including and excluding income generated from the sale of carbon credits.

Table 3. Simplified Cash Flow Analysis With and Without Income from the Sale of Carbon Credits.

Baneasa 1	Alternative 1		Alternative 2		Alternative 3	
	No CO_2 Credits sale	With CO_2 Credits sale	No CO_2 Credits sale	With CO_2 Credits sale	No CO_2 Credits sale	With CO_2 Credits sale
Project Net Present Value (Thousand $)	612	1,109	864	1,111	0.59	NA
Levelized unit heat cost ($/MWh)	21.36	21.30	20.21	20.21	24.15	NA
Internal Rate of Return (%)	13	16	20	23	10	NA
Baneasa 2						
Project Net Present Value (Thousand $)	440	940	639	803	0.53	NA
Levelized unit heat cost ($/MWh)	21.28	21.20	19.83	19.93	23.83	NA
Internal Rate of Return (%)	13	15	19	21	10	NA

Based on a critical review of the different alternatives, the project team recommended the second alternative for Baneasa 1 and Baneasa 2.

Product(s): Simplified cash flow analysis

5. Conducted a Full Analysis of the Investment, Financing and Profitability Parameters.

Once the best alternative was selected, the project team conducted a risk analysis, a sensitivity analysis and calculated projected cash flows, profit and loss statements and a financial analysis under the financing terms described above. The results were as follows:

	Baneasa 1	Baneasa 2
Total Project Cost, ($ millions)	1.508	1.299
Profitability	1.061	1.06
Return on Investment – ROI	12.53	12.17
Internal Rate of Return – IRR (%)	21.99	20.34
Business Net Present Value – NPV ($)	266,221	201,888

The project team concluded that the investment is profitable in both cases. The ROI is higher than the capital costs, and the NPV is positive. Three financing alternatives were considered: 1) a public/private partnership, 2) a loan from an international financing organization (EBRD, EIB, etc.), and 3) supplier credit. The team recommended the third option, supplier credit, and prepared a loan repayment schedule.

Products(s): Financial analysis and project financial indicators

6. **Disseminated project results.**

The findings of the project were widely disseminated. The project leader facilitated a presentation of the EcoLinks project results at four conferences attended by energy companies and equipment suppliers. The project team prepared a leaflet with simple and practical measures on how to save heat in apartment buildings. The leaflet was distributed in the target area.

Product(s): 1) Presentations 2) Leaflet

Project Benefits

There are several benefits generated by this project. They include capacity building through very good teamwork and an outreach campaign, and notable economic and environmental benefits including cost savings and reductions in greenhouse gas emissions from improving energy efficiency.

Capacity Building Benefits

The heating company RADET of Bucharest gained valuable knowledge and experience on how to improve its economic and environmental performance regarding heat generation through a transfer of technology and information from the US partner (Advanced Engineering Associates International, Inc) and the Romanian partner (Institutul de Studii si Proiectari Energetice SA). A methodology was developed that systematically evaluated various technological options. A detailed environmental and economic analysis of each option was performed in order to select the most suitable one for RADET. This process built and encouraged continuous teamwork amongst the project participants.

The project activities and results were presented at four large conferences including a nationwide forum that involved representatives of other heat and equipment suppliers in Romania.

The project also included a survey of households and associations. The survey results provided the utility with a great deal of information on how its services are perceived, and heat and cost saving measures that residents have undertaken or plan to undertake that may have a positive or a negative impact on their business. Moreover, the level of awareness of heat consumers was raised though a public outreach campaign that involved the distribution of a leaflet on practical and cost saving measures regarding heat consumption.

Environmental Benefits

The environmental benefits associated with the replacement of the existing Heat-Only Boiler Plant with a modern, combined heat and power unit are numerous. The total CO_2 emissions are expected to decrease by approximately 37% (approx. 5,000 t/yr.); CO emissions by 29% (1.1 t/yr.); NO_2 emissions by 29% (9 t/yr.). Additionally, electricity transmission losses through the networks are practically reduced to zero with on-site generation further increasing efficiency and reducing environmental impacts compared to the existing system.

Economic Benefits

This project not only provides environmental benefits but also generates economic benefits. Under the recommended option, the project generates a Net Present Value (NPV) of approximately $266,000 for Baneasa 1 and $202,000 for Baneasa 2 with an Internal Rate of Return (IRR) of 22% and 20% respectively. The heat unit cost was calculated at $20.5/MWh (5 % lower than the current cost assuming fuel costs will rise by 55 % throughout the lifetime of the project). After project implementation, Baneasa 1 will be able to sell approximately 8,400 MWh per year and Baneasa 2, approximately 7,000 MWh per year to the grid for an additional income of $420,000 per year and $350,000 per year respectively.

Lessons Learned

The following lessons were learned during this project:

- Good cooperation and sustained communication between the three project partners was essential for the success of the project.
- Previous work experience and collaboration between partners facilitated the project's development.
- Procurement of equipment for state owned entities can be very burdensome and lengthy. This challenge, however, can be overcome by starting the procurement process as early as possible.
- Modification of old installations to allow for new equipment (heat meters, in this case) may involve several challenges due to the poor state of the pipes, valves, etc. A conservative time factor should be incorporated into the work plan to allow for implementation within the project time frame.

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